Pasting properties of Tamarind (*Tamarindus indica*) kernel powder in the presence of Xanthan, Carboxymethylcellulose and Locust bean gum in comparison to Rice and Potato flour

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Abstract Effects of addition of different levels of gums (xanthan, carboxymethylcellulose and locust bean gum) on the pasting properties of tamarind kernel, potato and rice flour were studied by using Rapid Visco-Analyzer (RVA). Tamarind kernel powder (TKP) varied significantly ($P<0.05$) from rice and potato flours with respect to its highest protein, ash and fat contents. The results of RVA analysis indicated that pasting properties of flour/gum mixtures were dependent upon the concentration and type of the gums. Peak, breakdown and final viscosity increased with increase in gum concentration in the flour/gum mixture, but the effect was more pronounced for rice and potato flour than for TKP which showed much lower viscosity responses to all of the gums. Among the three gums studied, the increase in viscosity was significantly higher with addition of locust bean gum followed by xanthan while the lowest was observed with carboxymethylcellulose.

Keywords Tamarind kernel · Pasting · Xanthan · CMC · Locust bean gum

Introduction

Tamarind (*Tamarindus indica* L.) grows in more than 50 countries of the world. The major areas of production are in Asian countries like India, Bangladesh, Sri Lanka, Thailand and Indonesia (Kumar and Bhattacharya 2008). Tamarind fruit is a brown pod-like legume which contains a soft acidic pulp (about 55%), many hard-coated seeds (34%), 11% shell and fiber in a pod (Rao and Srivastava 1974). Pods contain 1 to 12 fully formed seeds which are very hard, shiny, reddish, or purplish brown, flattened, and each is enclosed in a parchment like membrane. The seed, a by-product of the tamarind pulp industry, is an underutilized or waste material. The seed comprises of seed coat or testa (20–30%) and the kernel or endosperm (70–80%). The seeds are important source of carbohydrates, protein, fat and valuable amino acids (Shankaracharya 1998). India produces about 0.3 million tons of tamarind yearly, of which the seed constitutes about 30–34% of the whole fruit (Kumar and Bhattacharya 2008). Tamarind seed has many uses though the major industrial use is in the form of tamarind kernel powder (TKP) (Rao and Srivastava 1974). The isolated proteins or TKP from roasted TKP can be used to prepare jelly and fortified bread and biscuit. TKP can be supplemented with other legume seeds to prepare nutritious balanced foods (Bhattacharya et al. 1994). TKP may be used as a dehydrating agent in making powdered products and as an emulsifying agent for essential oils (Vinod 1997), in cakes (Goto et al. 1994) and chewing gums (Anon 1989).

Hydrocolloids or gums are water-soluble, high molecular weight polysaccharides that find wide application in the

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food industry, optimising the rheological and textural characteristics of food systems (Tiwari et al. 2010). They are easily dissolved or dispersed in water and under appropriate conditions can produce an increase in viscosity (Salazar-Montoya et al. 2002). Starches and gums are often used together in food systems to provide proper texture, control moisture, and water mobility, improve overall product quality and stability, reduce costs, and facilitate processing (Shi and BeMiller 2002; Mali et al. 2003). Properties of one hydrocolloid can often be modified by interaction with other gums (Jana et al. 2010). To assess the importance and feasibility of any gum or hydrocolloid in food and other industries, the viscosity profile is generally considered as one of the important parameters (Goyal et al. 2007). Rapid Visco-Analyzer (RVA) can be used as a research tool for quickly demonstrating the effects of different hydrocolloids on starch cooking properties, which are unique for each starch type and gum type (Bahnassey and Breene 1994). Each hydrocolloid affects in a different way the pasting properties of starch (Christianson et al. 1981; Rojas et al. 1999) depending upon the molecular structure of hydrocolloids (Sudhakar et al. 1996) and ionic charges of both starches and hydrocolloids (Shi and BeMiller 2002).

The flow behavior of TKP dispersion in water is an important functional property in characterizing the material, the product development, and for the design of the processing units (Kumar and Bhattacharya 2008). The rheological behavior of TKP dispersion has been previously studied (Prabhanjan 1989; Bhattacharya et al. 1991; Prabhanjan and Ali 1995; Yamanaka et al. 2000; Salazar-Montoya et al. 2002). Literature regarding pasting properties of TKP in the presence of different gums is scarce but it is a topic of high industrial significance. The blends of TKP with gums are useful in commercial applications where thickening, suspending, emulsifying, film forming and gel forming properties are needed (Kumar and Bhattacharya 2008). Tamarind seed is a typical underutilized raw material in the places where it is grown but there is a scope to make it more useful. Though there are industrial uses for decorticated seeds as a low cost sizing material in jute and textile industries, there have been few uses of TKP as an additive in food formulations (Kumar and Bhattacharya 2008). The excellent gelling and adhesive characteristics of decorticated seed powder will widen the scope of utilization of TKP in food industries. Keeping the objective of enhancing prospects of utilizing TKP in industrial applications in mind, a study was undertaken to see the effect of different levels of gums (xanthan, carboxymethylcellulose, locust bean gum) on the pasting properties of TKP in comparison to rice and potato flour.

Materials and methods

Materials Tamarind seeds, potato tubers and rice flour were procured from the local market. Xanthan gum was obtained from John Baker Inc. Colorado U.S.A., Carboxymethylcellulose from Central Drug House Pvt. Ltd., Bombay, India and Locust bean gum was obtained from Wilson Laboratories, Bombay, India.

Preparation of Tamarind kernel powder (TKP) and potato flour Kernels of tamarind were dehusked after breaking open them. The decorticated seeds were then ground in a laboratory mixer and passed through sieve no. 72 (210 microns) to obtain TKP. For the preparation of potato flour, potatoes were washed, sliced, blanched and dried at 50 °C for 5 h in a cabinet drier. They were then ground in a laboratory mixer and passed through sieve no. 72 (210 microns) to obtain flour. All the flour samples were packed in air tight containers. The samples were estimated for their moisture, ash, fat, and protein content by employing the standard methods of analysis (AOAC 1984). The carbohydrate content was calculated by difference. Flours samples without gum addition were the control samples and were designated as native flours.

Pasting properties The pasting properties of TKP and flour samples were evaluated using a Rapid Visco Analyzer (RVA-3D, Newport Scientific, Warriewood, Australia) following the method as described by Kaur and Singh (2005). Samples were prepared by combining flour (2.5 g) and distilled water to keep the total sample size at 28 g and with the inclusion of 0.0, 0.1, 0.2, 0.4 and 0.5 g of each of the different gums and a flour concentration of 8.9%. Each flour/gum mixture was poured into an aluminum canister, stirred manually with the plastic paddle for 20–30 s to disperse the sample before insertion into RVA machine. Parameters recorded were peak, trough (minimum viscosity at 95 °C), final viscosity (viscosity at 50 °C), breakdown viscosity, and set back viscosity. All the measurements were replicated thrice.

Statistical analysis The data reported in all the tables were average of triplicate observations. The data were subjected to one-way analysis of variance (ANOVA) using Minitab Statistical Software version 13 (Minitab Inc., USA).

Results and discussion

Chemical composition The chemical characteristics of TKP, rice and potato flours are reported in Table 1. Proximate composition varied significantly ($P < 0.05$) among the different

Table 1 Proximate composition of tamarind kernel powder (TKP), rice and potato flours^{a,b}

Component (%)	TKP	Rice flour	Potato flour
Moisture	5.22±0.2 ^c	8.82±0.4 ^e	7.48±0.3 ^d
Ash	3.25±0.10 ^c	0.50±0.09 ^c	1.91±0.10 ^d
Crude fat	9.65±0.09 ^c	1.67±0.06 ^d	0.34±0.04 ^c
Crude protein	15.76±0.53 ^c	7.00±0.29 ^d	2.19±0.13 ^c
Carbohydrate	71.34 ^c	90.83 ^d	95.56 ^c

^a Mean followed by same letter in a row do not differ significantly ($p < 0.05$)

^b Mean (±SD) of triplicate analysis

flours. Moisture, ash and crude protein contents of samples varied from 5.22 to 8.82%, 0.50 to 3.25%, and 2.19 to 15.76%, respectively. The fat and protein content of the flours followed the order: tamarind>rice>potato. Among the three flours studied, TKP varied significantly ($P < 0.05$) with respect to its highest protein, ash and fat contents. The results obtained for TKP in the present study corroborated well with those reported by Prabhanjan and Ali (1995) and Marathe et al. (2002). They observed moisture and protein contents of 8.8% and 18.7%, and 8.6 and 14.3%, respectively in defatted TKP. Carbohydrate content (calculated by difference) was the highest in potato (95.56%) while the lowest was observed in TKP (71.34%). Gunasena and Hughes (2000) reported moisture, ash, fat, protein and carbohydrate contents in the range of 11.4–22.7%, 2.4–4.2%, 3.9–16.2%, 15.0–20.9% and 65.1–72.2%, respectively for tamarind kernel. The variation in the chemical composition between flours from different botanical sources in the present study could be due to inherited differences.

Pasting properties Rapid visco analyzer (RVA) measures changes in viscosity of materials under varying heat and shear, primarily using a typical RVA pasting profile (Stevenson and Inglett 2007). The pasting characteristics of tamarind, rice and potato flours without gum additions (controls) determined by RVA are illustrated in Fig. 1. Significant differences were observed among the flours tested in their behavior during heating and cooling cycles in excess of water. When a sufficient number of granules become swollen, a rapid increase in viscosity occurs, known as peak viscosity (PV) (Kaur et al. 2007). PV of different native flours varied from 386–684 cP, the highest for potato and the lowest for TKP. Lowest PV of TKP could be attributed to its highest protein content. Olkku and Rha (1978) reported that protein forms complexes with the starch granule surface, preventing the release of exudates and lowering the peak viscosity. Bonding forces within

granule could also affect their swelling behavior. The strong bonding forces in tamarind permit slower swelling and consequently its lower peak viscosity than the weaker bonding forces in potato flour. Trough viscosity (TV) was found to be the lowest for TKP (108 cP) and the highest for potato flour (552 cP) (Fig. 1). TV has been reported to be influenced by the granule swelling, friction between swollen granules, extent of amylose leaching, and amylose-lipid complex formation (Liu et al. 1997). Breakdown viscosity (BV) of the flours ranged between 12–278 cP. Highest BV was observed in TKP, thereby indicating its lower thermostability. On heating and subsequent cooling of aqueous starch dispersions, paste viscosity rises, retrogradation and formation of a gel are the well established events. These are attributed to the breakdown of the granular structure of starch, hydration of the network and intermolecular associations (Prabhanjan and Ali 1995). Final viscosity (FV) and setback (SB) of the flours ranged between 317–1102 cP and 193–550 cP, respectively (Fig. 1). Potato flour showed significantly higher FV and SB, followed by rice and TKP. SV is measure of syneresis of starch upon cooling of cooked starch pastes (Singh et al. 2004). Lower SB of rice and TKP are indicative of its lower tendency to retrograde. The results of RVA indicated that SB of TKP was comparable to rice flour and could be used to replace it in different food formulations such as soups and sauces which undergo loss of viscosity as a result of retrogradation. PV, BV, FV and SB values of 950 BU, 350 BU, 1240 BU and 590 BU, respectively for TKP at 8% concentration has been observed earlier (Prabhanjan and Ali 1995). Although starch is quantitatively major component to control the pasting /thermal properties, temperature induced changes in non starchy polysaccharides and proteins also contribute to

Fig. 1 Peak (PV), trough (TV), breakdown (BD), final (FV) and setback (SB) viscosity of tamarind kernel powder, rice and potato flours in the absence of gums. $n=3$

Table 2 Pasting properties of TKP in the presence of 0.1, 0.2, 0.4 and 0.5 g of xanthan, CMC and locust bean gum as measured by RVA^a

Sample	PV (cP)	BV (cP)	SB (cP)
Native TKP	386±10	278±9	209±12
Xanthan gum			
(0.1 g)	570±16	387±11	238±11
(0.2 g)	860±12	577±12	377±16
(0.4 g)	2192±22	1371±8	1044±10
(0.5 g)	3056±20	2085±12	1881±14
CMC gum			
(0.1 g)	461±9	299±10	231±5
(0.2 g)	677±6	446±12	291±10
(0.4 g)	1788±12	1030±10	520±14
(0.5 g)	2369±20	1456±12	885±7
Locust bean gum			
(0.1 g)	799±10	527±9	310±7
(0.2 g)	1497±16	916±10	670±5
(0.4 g)	3341±20	2335±19	1947±10
(0.5 g)	4124±29	3317±20	2999±29

PV peak viscosity; BV breakdown viscosity; SB: setback viscosity

^a Means of triplicate observations (± SD)

the gelling, and pasting properties by way of swelling, denaturation and unfolding (Kaur and Sandhu 2010).

Table 2 presents the average values for the pasting parameters of TKP in the presence of 0.1, 0.2, 0.4, 0.5 g of additional xanthan, carboxy methyl cellulose (CMC) and locust bean gum (LBG). Pasting properties varied with the gum source and the level of gum addition. Both PV and BV tended to increase significantly ($P<0.05$) with an increase in concentration of gums in the mixture. PV often correlates with the quality of end-product and also provides an indication of the viscous load likely to be encountered by a mixing cooker while the ability of starches to withstand heating at high temperature and shear stress is an important factor in many processes (Ragaei and Abdel-Aal 2006). SB increased significantly from 209 cP in the native TKP and reached a maximum of 2999 cP with the addition of LBG at 0.5 g level in the mixture. The effect of LBG at 0.5 g concentration was more pronounced in comparison to xanthan and CMC as the mixture exhibited the highest PV (4124 cP), BV (3317 cP), and SB (2999 cP) in comparison to control sample (Table 2). This suggests that LBG allowed the starch granules to swell freely, while xanthan and CMC made them more difficult to swell.

RVA pasting parameters of rice flour in the presence of the same concentration of the same three gums are shown in Table 3. As was noticed with TKP, all the pasting parameters increased with increase in gum concentration in rice flour. PV with addition of xanthan gum ranged between 1701–5411 cP, with CMC 1457–5193 cP and with LBG the

Table 3 Pasting properties of rice flour in the presence of 0.1, 0.2, 0.4 and 0.5 g of xanthan, CMC and locust bean gum as measured by RVA^a

Sample	PV (cP)	BV (cP)	SB (cP)
Native flour	433±21	12±3	193±8
Xanthan gum			
(0.1 g)	1701±16	110±9	121±10
(0.2 g)	2855±18	419±11	661±11
(0.4 g)	4790±28	633±6	2411±16
(0.5 g)	5411±35	1104±12	3707±19
CMC gum			
(0.1 g)	1457±11	99±9	127±12
(0.2 g)	2874±21	373±13	1056±14
(0.4 g)	4157±19	568±18	2015±28
(0.5 g)	5193±29	768±6	3413±31
Locust bean gum			
(0.1 g)	1827±12	127±6	481±11
(0.2 g)	3556±19	614±7	1730±16
(0.4 g)	6722±26	1078±16	3205±24
(0.5 g)	8525±33	2226±14	4173±19

PV peak viscosity; BV breakdown viscosity; SB setback viscosity

^a Means of triplicate observations (± SD)

values were 1827–8525 cP. SB also showed a significant increase from 193 cP in native and reached a maximum of 4173 cP with the addition of 0.5 g of LBG. The maximum

Table 4 Pasting properties of potato flour in the presence of 0.1, 0.2, 0.4 and 0.5 g of xanthan, CMC and locust bean gum as measured by RVA^a

Sample	PV (cP)	BV (cP)	SB (cP)
Native flour	684±12	132±9	550±10
Xanthan gum			
(0.1 g)	1444±31	189±10	1111±14
(0.2 g)	2630±16	346±13	2145±20
(0.4 g)	6433±23	1707±20	4127±16
(0.5 g)	8337±32	3709±32	6578±25
CMC gum			
(0.1 g)	1212±17	105±9	947±12
(0.2 g)	1936±20	323±12	1861±7
(0.4 g)	3634±30	942±15	5919±28
(0.5 g)	4609±37	1833±19	8031±39
Locust bean gum			
(0.1 g)	1805±24	246±6	1393±18
(0.2 g)	3245±31	639±12	4105±26
(0.4 g)	8500±40	3885±18	7353±33
(0.5 g)	11999±24	4949±27	8279±31

PV peak viscosity; BV breakdown viscosity; SB setback viscosity

^a Means of triplicate observations (± SD)

effect on viscosity was shown by LBG at 0.5 g gum concentration in the mixture. Starches are known to participate in synergistic interactions with hydrocolloids (Adamu and Jin 2002). The gelatinization characteristics of starches in the presence or absence of gums are influenced by the morphological structure of gum in which the starch granules were embedded, the swelling power of the granules themselves, and the electrostatic interactions between the starch granules and gum molecules. The dominance of each factor which could play a major role in the pasting characteristics of the starch–gum mixtures was dependent on the combination of each specific starch and gum (Chaisawang and Supphantharika 2006).

The RVA pasting parameters for potato flour in the presence of added xanthan, CMC and LBG are compared in Table 4. General behavior was typical with flour/gum system studied. All the pasting parameters showed an increase with the increase in gum concentration except with the addition of 0.1 g CMC wherein the BV was lower than when no gum was added. PV increased from 684 cP in the native flour and reached a maximum of 11999 cP with the addition of LBG at 0.5 g level. Among the three gums studied, LBG affected the pasting properties of potato flour the most by exhibiting highest PV (11999 cP), BV (4949 cP) and SB (8279 cP).

The viscosity of a mixed system is greatly higher than starch alone since most biopolymers are strongly hydrophilic and compete with starch for water (Christianson et al. 1981; Sudhakar et al. 1996). The increase in viscosity with increase in gum concentration in the mixture was more pronounced for rice and potato flour than for TKP which showed much lower viscosity responses to all of the gums. Among the three gums added to different flours, xanthan gum affected potato flour the most which exhibited the highest PV, BV and SB upon its addition. CMC addition increased PV of rice flour to the greatest extent while BV and SB of potato flour showed significantly higher values in the presence of CMC. The same trend was noticed upon addition of LBG to potato flour which showed maximum viscosity values. TKP was observed to be the least affected by xanthan and CMC addition.

Conclusion

The results showed that TKP differed significantly from rice and potato flours studied with respect to its highest BV and the lowest FV. Viscosity of flour/gum mixture after heating and cooling was greater than in flour alone. The extent of the rise in viscosity with the addition of gums depended upon the type of gum added and the type of flour used. For all the flours in the presence of different gums,

PV increased with increase in gum concentration but the effect was more pronounced for rice and potato flour than for TKP. Among the three gums, the viscosity values were the highest for flour/LBG mixtures in comparison to flour/xanthan and flour/CMC mixtures. Pasting properties of flour can be manipulated by addition of gums at different levels and the level can be determined on the basis of desired pasting properties. The significant changes in viscosity which occurred upon the gum addition are of great industrial importance. Effective control and utilization of these especially the heat stability and retrogradation tendency is necessary to obtain food products of good quality. The results obtained also suggest the substitution of rice and potato flour with TKP in formulation of different type of food products such as sauces, soups, puddings etc.

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